

# Geotechnical Problems & Solutions

## *Geotechnical Problems and Practical Solutions*



Presented by The Geotechnical Engineering Unit  
Njoroge Wainaina, P.E., State Geotechnical Engineer



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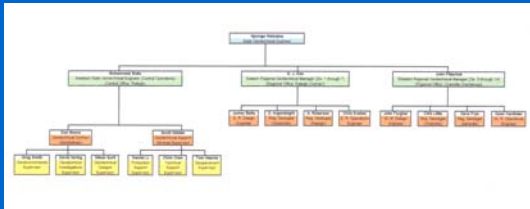
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## *Geotechnical Engineering Unit Organization*



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## *Geotechnical Problems and Practical Solutions*

- Tom Hearne, P.E., GeoPavement Supervisor
  - Undercut Issues
  - Stabilized Subgrade Strength Issues
- Chris Kreider, P.E., Eastern Region Operations Engineer
  - Bearing Pile Issues
  - Retaining Wall Issues
- Dean Hardister, P.E., Western Region Operations Engineer
  - Rock Issues
  - Drilled Pier Issues
- Scott Hidden, P.E., Support Services Supervisor
  - Present Improvements/Changes/Solutions

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# Geotechnical Problems & Solutions

## *Undercut Issues*

Geotechnical Unit was formed in 1953 for the purpose of dealing with undercut issues.



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## *Undercut Issues*

Would you undercut this?



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## *Undercut Evaluation*



- Depth
- Soil Type (PI)
- Moisture Content
- Strength

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# Geotechnical Problems & Solutions

## Strength Evaluation - Proof Rolling



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## Strength Evaluation - DCP

(Dynamic Cone Penetrometer)



Penetration per blow > 1.5 inches (CBR 8) ---  
need to consider undercut options

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## Options to Deep Undercut



- Stabilization (lime)
- Dry out (underdrain + time)
- Shallow undercut/fabric & select material
- Geogrids

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# Geotechnical Problems & Solutions

## *Fabric & Select Material*



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## *Undercut Issues*

**Who should you contact with questions about undercut issues?**

**Regional Geotechnical Operations Engineer**

**Chris Kreider** (Divisions 1-7)  
(919) 662-4710 (O) or 218-4205 (Cell)

**Dean Hardister** (Divisions 8-14)  
(704) 455-8902 (O) or 305-4163 (Cell)

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## *Bearing Pile Issues*



- Over the last 3 years:
  - Installed over 650,000LF of piles
  - For a cost in excess of 20 million dollars
- Typical pile types used:
  - Concrete Piles
  - Steel H Piles
  - Steel Pipe Piles
  - Composite Piles

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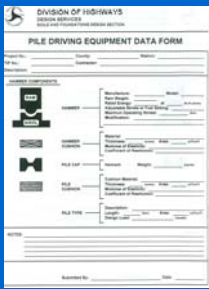
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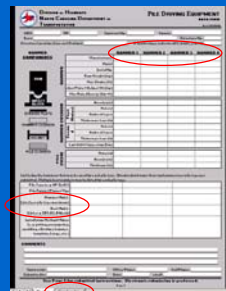
# Geotechnical Problems & Solutions

## New Pile Driving Equipment Data Form

Old Form

A scanned image of the old Pile Driving Equipment Data Form. It is a paper-based form with various sections for project information, equipment details, and personnel. The form is titled "PILE DRIVING EQUIPMENT DATA FORM" and includes fields for project name, location, and dates.

New Form (in Excel)

A screenshot of the new Pile Driving Equipment Data Form in Excel format. The form is displayed in a spreadsheet layout with various columns and rows for data entry. Red circles highlight specific areas of the form, including the "PROJECT INFORMATION" section and the "EQUIPMENT INFORMATION" section.

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## New Pile Driving Equipment Data Form

Submit one hard copy of the completed form to the Resident Engineer.

Submit a second copy of the completed form to the Geotechnical Engineering Unit.

For the Geotechnical Engineering Unit, select one of the following methods of submission.

### Method 1, Electronic Submission (preferred)

Submit a digital file as an email attachment to the appropriate email addresses below.

The digital file may be a scanned image of the completed and signed form, or an Excel file.

Instructions for Excel file submission:

- Key in the submitter's name at the bottom of the form, and submit from this person's email address. (The return email address must match the typed name and email address on the form.)
- Submit the digital form in Excel 97 format or older.

### Method 2, US Mail or Other Delivery Service Submission

Complete and sign a paper copy of the form. Send the form to the appropriate address below.

### Method 3, Facsimile Submission

Complete and sign a paper copy of the form. Fax the form to the appropriate Fax number below.

For Divisions 1-7, Eastern Regional Office in Garner (Raleigh) is mailing address and fax location and K.J. Kim and Chris Kreider are e-mail recipients.

For Divisions 8-14, Western Regional Office in Harrisburg (Charlotte) is mailing address and fax location and John Pilipchuk and Dean Hardister are e-mail recipients.

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## New Pile Driving Equipment Data Form

A screenshot of the North Carolina Department of Transportation (NC DOT) website. The website is titled "Welcome to NC DOT" and features a navigation menu on the left with links to various services. A red circle highlights the "Forms and Publications" link in the menu. The main content area displays a list of links and information related to the department's operations.

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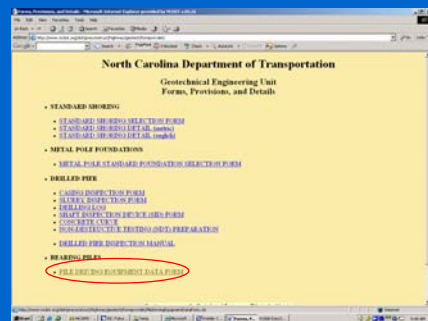
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# Geotechnical Problems & Solutions

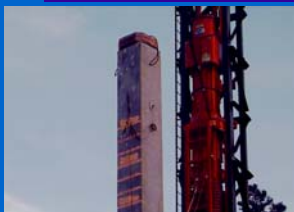
## New Pile Driving Equipment Data Form



## New Pile Driving Equipment Data Form



## Pile Driving Analyzer (PDA)



### What is a PDA?

A piece of equipment used to monitor piles for damage during driving and estimate pile capacity.



### How does it work?

Instruments are attached to the pile head and linked to a computer with cables to record stresses and energy.

# Geotechnical Problems & Solutions

## *Pile Redrives or Restrikes*

- Restrikes/Redrives are used to take advantage of soil setup or freeze
- U-3329 Battleboro (Edgecombe County) use of redrives/restrikes saved \$80k (shorter piles)
- B-2938 White Oak River (Onslow County) non-use of redrives/restrikes resulted in a cost overrun of \$468k (for additional pile length)



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## *Bearing Pile Issues*

- In Subarticle 450-8(A), 2002 Standard Specifications say:
  - “Drive piles to the required bearing capacity in a continuous operation unless stopped due to insufficient length or other emergencies. After the pile driving operation stops, operate the hammer a sufficient number of blows to overcome the force of built up friction before resuming normal record keeping and checking final bearing.”
- In Subarticle 450-7(A), 2006 Standard Specifications say:
  - “Drive piles to the required tip elevation or penetration into natural ground, whichever is lower, in a continuous operation unless stopped due to exceeding the maximum blow count or the allowable pile driving stresses, insufficient pile length, or other reasons approved by the Engineer. Once the required embedment is achieved, the Engineer may require the Contractor to stop driving and wait before restriking to allow for soil setup.”
- Added Subarticle 450-7(E) entitled “Redriving Piles” to 2006 Standard Specifications

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## *Redriving Piles*

“Once the required pile embedment has been achieved, the Contractor may choose to or the Engineer may require restriking or redriving piles. If the Contractor chooses to stop driving and then restrike or redrive piles, no payment will be made for restrikes or redrives. If the Engineer requires the Contractor to stop driving and then restrike or redrive piles, payment will be made in accordance with Article 450-9.”

“When the Engineer requires restrikes or redrives, the Engineer will determine the time to wait after stopping driving and the number of restrikes or redrives. However, the maximum number of restrikes or redrives per pile during any 48 hour period will not exceed three. The minimum time separation between restrikes or redrives required by the Engineer is 4 hours.”

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# Geotechnical Problems & Solutions

## *Redriving Piles*

“Use the same approved pile driving methods, equipment and compressed pile cushion from the previous drive to restrike or redrive the pile unless the cushion is unacceptable due to deterioration, in which case use another acceptable cushion. Do not use a cold diesel hammer for a restrike or redrive, unless in the opinion of the Engineer, it is impractical to do otherwise. In general, warm up the hammer by applying at least twenty (20) blows to a previously driven pile or timber mats on the ground.”

“*Pile redrives* will be measured and paid for per each as the actual number of restrikes or redrives required by the Engineer. No payment will be made for restrikes or redrives when the Contractor chooses to restrike or redrive piles.”

“Payment will be made under:

Pile Redrives

Each”

## *Pipe Pile Plates*

- “PIPE PILE PLATES ARE REQUIRED FOR THE PIPE PILES AT BENT NO. \_\_\_\_\_. USE PIPE PILE PLATES WITH A DIAMETER EQUAL TO THE PIPE PILE DIAMETER. SEE SECTION 450 OF THE STANDARD SPECIFICATIONS. *or* PIPE PILE PLATES MAY BE REQUIRED FOR THE PIPE PILES AT BENT NO. \_\_\_\_\_. THE ENGINEER WILL DETERMINE THE NEED FOR PIPE PILE PLATES AFTER DRIVING TEST PILES OR A FEW INITIAL PRODUCTION PILES AS DIRECTED BY THE ENGINEER. USE PIPE PILE PLATES WITH A DIAMETER EQUAL TO THE PIPE PILE DIAMETER. SEE SECTION 450 OF THE STANDARD SPECIFICATIONS. *or* PIPE PILE PLATES ARE NOT REQUIRED FOR THE PIPE PILES AT BENT NO.”

- Added “Pipe Pile Plates” pay item to 2006 Standard Specifications

## *Pile Driving Analyzer (PDA)*

- Developed “Pile Driving Analyzer” Special Provision, formerly “Bearing Piles” Special Provision
  - Effective 5/05 letting
  - Revised for 7/06 letting as a result of changes to “Bearing Piles”, Section 450 in the 2006 Standard Specifications
- Allows for either the Contractor to retain a PDA Consultant or the Geotechnical Engineering Unit (GEU) to perform the PDA testing
- When a PDA Consultant performs testing, lists requirements for PDA report and analysis
- Payment for PDA based on two pay items (one per pile):
  - “PDA Testing” for collecting data, performing analysis and furnishing report (no payment when GEU performs testing)
  - “PDA Assistance”, formerly “Dynamic Load Tests”, for Contractor support



# Geotechnical Problems & Solutions

## *Rock Issues*

### Rock Quantity Claim Issues

- Excavated rock paid for
  - as “Pre-Splitting of Rock”, Section 228 and
  - as “Unclassified Excavation”, Section 225
- Rock estimate provided in the Earthwork Balance Sheet

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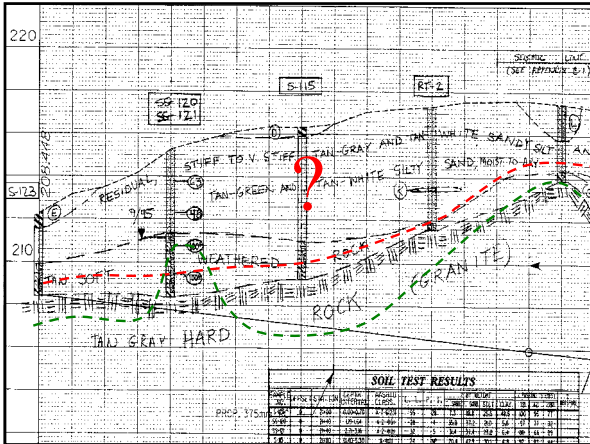
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- If **TOO LITTLE** rock is estimated, excess materials need to be **WASTED** since rock **SWELLS** when placed for embankment
- If **TOO MUCH** rock is estimated, off-site **BORROW** will be required due to the **LACK** of **SWELL**

# Geotechnical Problems & Solutions




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## Rock Issues

### Rock Quantity Claim Issues

- Since October 2004, three Verified Claims related to quantities exceed

\$38,000,000

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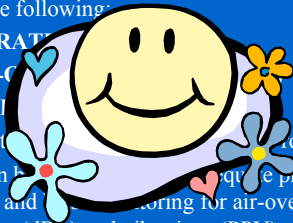
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## Rock Issues

### Property Damage Claim Issues

- Damage due to rock blasting can occur from any or all of the following:
  - VIBRATION
  - AIR-C
  - FLYING
- Goal is to minimize damage to property and rock blasting
- Risk can be reduced by pre-blast surveys and monitoring for air-overpressure, e.g. noise (dBL) and vibrations (PPV)




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# Geotechnical Problems & Solutions

*Rock Blast*



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# Geotechnical Problems & Solutions

## *Why do we need a new blasting SP?*

- Laws have changed since 9/11
- Current specs are scattered and inadequate for a project with significant or substantial rock blasting
- Current requirements are inconsistent and many times, undefined
- We should and can do better in terms of safety, lower risk, less claims and property damage, higher quality controlled blasting and better submittals and record keeping

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## *Rock Blasting Special Provision*

- Developed “Rock Blasting” Special Provision
  - “Pre-Splitting of Rock”, Section 228 removed from 2006 Standard Specifications
  - “Excavation of Rock by Use of Explosives” Special Provision will not be used in most cases
  - Both of these are incorporated into new SP
- Articles 107-11, “Use of Explosives”, 107-12, “Protection and Restoration of Property” and 410-12, “Blasting Adjacent to Highway Structures” remain in the 2006 Standard Specifications and work with or without new SP

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## *What does Rock Blasting SP do?*

- Addresses all types of rock blasting including
  - production blasting
  - trench blasting
  - controlled blasting (pre-splitting, cushion blasting and trim blasting)
  - secondary blasting
  - blasting adjacent to highway structures
- Requires a Blaster-in-Charge
  - “The Blaster-in-Charge has complete responsibility for and total authority over the handling, use and security of explosives.”

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# Geotechnical Problems & Solutions

## *Blaster-in-Charge*



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## *What does Rock Blasting SP do?*

- Includes a current list of regulations and laws that should be followed
- Lists submittals and documentation requirements
- Allows for an independent Blasting Consultant to design blasts and prepare blast plans (note on plans)
- Defines when and where pre-blast surveys and blast monitoring are required
- Allows for an independent Blast Monitoring Consultant to do pre-blast surveys and blast monitoring (note on plans)

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## *What does Rock Blasting SP do?*

- Requires drilling records
- Allows for test blasts (note on plans)
- Defines blast design requirements for production blasts, controlled blasts and trench blasts
- Defines default vibration and air-overpressure (noise) warning and not-to-exceed levels and allows for different limits (note on plans)
- Standard SP and notes on plans provide flexibility to increase or decrease pre-blast survey and blast monitoring requirements and limit flyrock

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# Geotechnical Problems & Solutions

## *Retaining Wall Issues*



### CUT WALLS:

- Soil Nail Walls
- Tieback Walls
- Pile Panel Walls



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## *Retaining Wall Issues*

### FILL WALLS:

- Mechanically Stabilized Earth Walls (MSE)
- Modular Block Walls
- Gravity Walls and Cast-in-Place Walls



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## *MSE or Tieback Wall?*



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# Geotechnical Problems & Solutions

## *Retaining Wall Issues*

- Many different types of retaining walls
- Becoming more common; over last 3 years, constructed over 60 walls at a cost of over 20 million dollars
- Generally bid lump sum
- Generally contracted as post bid design
  - Department selects wall type, coordinates details (drainage, utility conflicts, etc.) and determines alignment and elevations
  - Contractor selects specialty subcontractor to design wall based on the profile view of the wall ("wall envelope") shown in the plans

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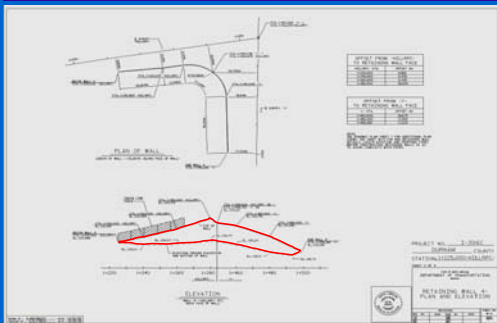
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## *Wall Envelope*



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## *MSE Wall Construction*

Was the wall envelope correct?



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# Geotechnical Problems & Solutions

## *Retaining Wall Issues*

Highway Design Branch issued new policy in July, 2005 changing/formalizing retaining wall responsibilities. Highlights of the policy and resulting changes are summarized below:

- The Geotechnical Engineering Unit is primarily responsible for most retaining walls. This includes responsibility for selecting wall type, coordinating details, preparing plans and handling wall submittals.
- Retaining wall plans will be in the Structure Plans and will be structure pay items except for when a wall(s) is/are the only structure(s) on the project.
- Retaining wall plans will have a profile view of the wall ("wall envelope") and a note requiring verification of the envelope if the ground line is contained within the envelope.
- Retaining walls will be structure pay items and most walls will be paid in per square foot (meter) of exposed face area.

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## *Retaining Wall Issues*

As a result of the new retaining wall policies, the following changes will be effective with the 7/06 letting (coincides with effective date for 2006 Standard Specifications and Standard Roadway Drawings):

- Section 842, "Gravity Retaining Walls" was re-written, re-numbered 453 and moved to Division 4, "Major Structures", in the 2006 Standard Specifications
- Roadway Standard Drawings 842.01, 842.02 and 842.03 were removed from the 2006 Roadway Standard Drawings
- A new Structure Standard Drawing for Gravity Retaining Walls has been developed
- "Submittal of Working Drawings" Special Provision was revised to define "Geotechnical Submittals" which includes retaining walls "The Resident Engineer will receive review comments and drawing markups for these submittals from the Geotechnical Engineering Unit."

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## *Stabilized Subgrade Strength Issues*

What are the two types of stabilizing agents commonly used for chemical stabilization by the Department?



- Lime
- Cement

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# Geotechnical Problems & Solutions

## *Stabilized Subgrade Strength Issues*



- Cores (difficult, not practical when strength is marginal)
- 7 day curing period (delays work)
- DCP (labor intensive, time consuming)

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## *Problems with Cores*



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## *Falling Cone Penetrometer (FCP)*



- Rugged
- Inexpensive
- Quick & easy to operate (pass/fail)

Penetration depth related to compressive strength.

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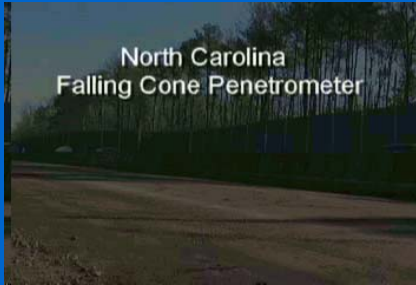
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# Geotechnical Problems & Solutions

## *Falling Cone Penetrometer (FCP)*



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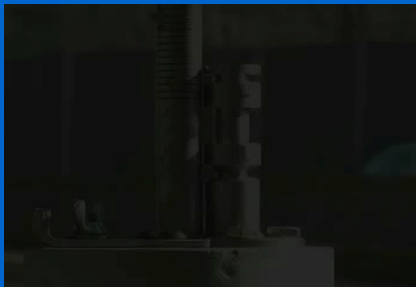
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## *Falling Cone Penetrometer (FCP)*



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## *What is the goal?*

Less Delay, Improved Uniformity



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# Geotechnical Problems & Solutions

## *Drilled Pier Issues*

Headaches, Heartbreaks & Stories from the Field

- What's New?
  - Polymer Slurry
- Typical Issues
  - Temporary Casing
  - Concrete Placement (wet vs. dry)

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# Geotechnical Problems & Solutions



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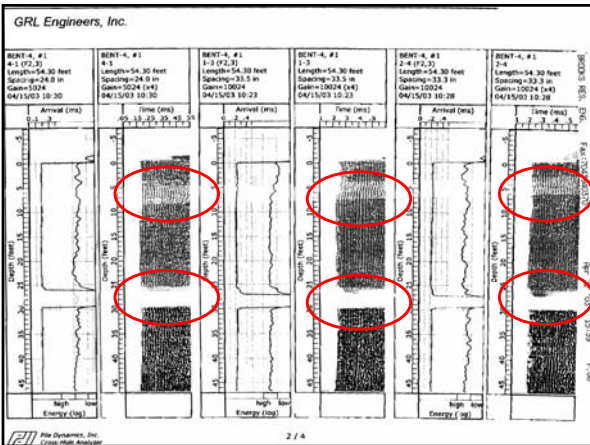
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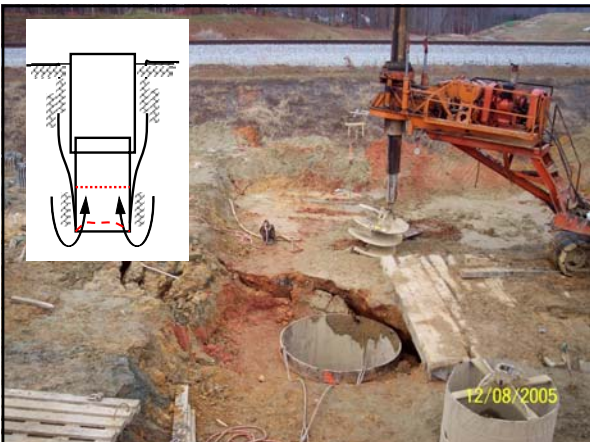
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# Geotechnical Problems & Solutions



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*Did we leave something out?*



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## *Drilled Pier Issues*

- Drilled Piers Special Provision and Standard Foundation Notes were revised effective 6/05 letting
- Changes provide Department with more options to control excavation methods and concrete placement

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# Geotechnical Problems & Solutions

## *Drilled Piers Special Provision*

“Do not twist, move or otherwise disturb temporary casings until the concrete depth in the casing is in excess of 10 feet above the bottom of the casing being disturbed.”

“If the head is greater than 30 feet, the Engineer may require a concrete depth greater than 10 feet. The head is defined as the difference between the highest piezometric head along the depth of the pier and the static water elevation inside the excavation.”

“If the Engineer requires a concrete depth greater than 10 feet, the Contractor may choose to either place concrete with this required concrete depth or place concrete with the wet method and a minimum concrete depth of 10 feet.”

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## *Drilled Piers Standard Notes on Plans*

- “DO NOT USE MULTIPLE TEMPORARY CASINGS IN A TELESOPED ARRANGEMENT TO STABILIZE DRILLED PIER EXCAVATIONS AT BENT NO. \_\_\_\_.”
- “DO NOT DEWATER THE DRILLED PIER EXCAVATIONS AT BENT NO. \_\_\_\_\_. CLEAN THE BOTTOM OF THE EXCAVATIONS WITH A SUBMERSIBLE PUMP OR AN AIRLIFT. WET PLACEMENT OF CONCRETE IS REQUIRED. SEE DRILLED PIERS SPECIAL PROVISION.”

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## *Bentonite Slurry*

- “DO NOT USE SLURRY CONSTRUCTION FOR DRILLED PIERS AT BENT NO. \_\_\_\_.” or “SLURRY CONSTRUCTION IS REQUIRED FOR DRILLED PIERS AT BENT NO. \_\_\_\_\_. SEE DRILLED PIERS SPECIAL PROVISION.”
- “When slurry use is not noted on the plans, slurry construction is an option.”

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# Geotechnical Problems & Solutions

## *Polymer Slurry*

- “DO NOT USE POLYMER SLURRY FOR DRILLED PIERS AT BENT NO. \_\_\_\_\_.” or “POLYMER SLURRY IS REQUIRED FOR DRILLED PIERS AT BENT NO. \_\_\_\_\_. SEE DRILLED PIERS SPECIAL PROVISION.”
- Drilled Piers Special Provision specifies three polymers:
  - SlurryPro EXL by KB Technologies
  - Super Mud by PDS Company
  - Shore Pac GCV by CETCO Drilling Products Group

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## *Polymer Slurry*

“Use polymer slurry and associated additives in accordance with the manufacturer’s guidelines and recommendations unless otherwise approved by the Engineer.”

“The Contractor should be aware that polymer slurry might not be appropriate for a given site. Polymer slurry should not be used for excavations in soft or loose soils as determined by the Engineer.”

“When using polymer slurry, a representative of the manufacturer must be on-site to assist and guide the Contractor during the construction of the first three drilled piers unless otherwise approved by the Engineer. This representative must also be available for on-site assistance to the Contractor if problems are encountered during the construction of the remaining drilled piers as requested by the Engineer.”

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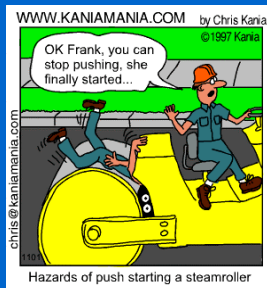
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## *Questions?*



- Undercut
- Bearing Piles
- Rock Issues
- Stabilized Subgrades
- Retaining Walls
- Drilled Piers

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